CLAIMS:

1. A cementitious pipe suitable for below ground use, wherein said pipe has a tubular wall of fiber-reinforced cementitious matrix or material capable of exhibiting pseudo strain hardening (PSH) behavior, said wall has a wall thickness to diameter ratio within a range, and the cementitious material and the range for said wall thickness to diameter ratio are such that the pipe exhibits characteristic behavior in diametral quasi-static bending (flexure) when subjected to the 3-edge bearing method, and wherein said behavior is such that a resultant stress versus relative displacement curve for the pipe when subjected to that method exhibits a substantially linear elastic region having a first slope within first limits and, from the limit of proportionality (LOP) for the elastic region to the modulus of rupture (MOR) for the pipe, a PSH region which, beyond a possible transition region, has a slope which is less than that of the elastic region and is within second limits.

2. The pipe of claim 1, wherein the wall has a relatively low wall thickness to diameter ratio.

3. The pipe of claim 1 or claim 2, wherein for a given wall diameter, the wall thickness is within a relatively narrow range, with the wall thickness range for a pipe having a wall of a given larger diameter being greater than the wall thickness range for a pipe having a wall of a given smaller diameter.

4. The pipe of claim 3, wherein the wall thickness range for a given wall internal diameter is as follows for the indicated pipe wall internal diameters:

| Wall Diameter | Wall Thickness Range |
|---|---|
| 225mm | 5 to 9mm |
| 375mm | 8 to 15mm |
| 750mm | 16 to 30mm |
| 2100mm | 45 to 85mm |

5. The pipe of claim 3, wherein the wall thickness range for a given wall internal diameter is as follows for the indicated pipe wall internal diameters:

| Wall Diameter | Wall Thickness Range |
|---|---|
| 225mm | 6 to 8mm |

| | |
|---|---|
| 375mm | 9 to 13mm |
| 750mm | 20 to 26mm |
| 2100mm | 55 to 75mm |

6. The pipe of any one of claims 1 to 5, wherein the pipe, while subjected to loadings generating stress up to the LOP, is able to function as a rigid pipe.

7. The pipe of any one of claims 1 to 6, wherein the pipe, at loadings generating stress levels in excess of the LOP and up to the MOR is able to function as a flexible pipe due to the effects of PSH.

8. The pipe of any one of claims 1 to 7, wherein the stress versus relative displacement curve, when tested by the 3-edge bearing method of Australian Standard AS4139-2003, has a value for the LOP of from about 4 to 12 MPa, such as from about 5 to 10 MPa, for example from 5 to 7 MPa.

9. The pipe of any one of claims 1 to 7, wherein the stress versus relative displacement curve, when tested by the 3-edge bearing method of Australian Standard AS4139-2003, has a value at the cracking strength of the matrix in initial testing of from about 4 to 12 MPa, such as from 5 to 10MPa, for example 5 to 7 MPa.

10. The pipe of claim 8 or claim 9, wherein said curve, when so tested, has a relative displacement ($\delta_1$) at the limit of elastic deformation of from about 0.3% to about 0.9%, such as from 0.4 to 0.8%, for example 0.6 to 0.8%.

11. The pipe of any one of claims 8 to 10, wherein said curve when so tested, has a first, transition part of the PSH region of the curve which ranged up to a relative displacement ($\delta_2$) of about 1.7%, such as from 1.1 to 1.5%, for example about 1.2%.

12. The pipe of any one of claims 8 to 11, wherein said curve, when so tested, has at least a major part of the PSH region which ranges up to a displacement ($\delta_3$) of about 11%, preferably within the range of from about 2% to about 11%, such as from about 3% to 10%, for example, from about 5% to about 9%.

13. The pipe of any one of claims 8 to 12, wherein said curve, when so tested, has a MOR of from about 10 to 20 MPa, such as from about 10 to 17 MPa, for example from about 10 to 15 MPa, such as about 11 to 15 MPa.

14. The pipe of any one of claims 8 to 13, wherein said curve has a slope ($S_1$) over the linear portion of the curve, within said first limits, of from about 1000 MPa to

about 1700 MPa, such as from 1000 MPa to 1650 MPa, for example about 1330 MPa to 1650 MPa.

15. The pipe of any one of claims 8 to 14, wherein at least a major part of the length of the PSH region of said curve has a positive slope ($S_3$) which ranges, within said second limits, from a very small positive value up to about 0.04 $S_1$ to 0.25 $S_1$, where $S_1$ is the slope of the curve over the linear position, such as about 0.05 $S_1$, and wherein said PSH region fluctuates in amplitude and said slope $S_3$ is the slope of a smoothed trend line for the PSH region.

16. The pipe of any one of claims 1 to 15, wherein said tubular wall is of substantially circular cross-section and of substantially constant cross-sectional form substantially throughout its length.

17. The pipe of any one of claims 1 to 16, wherein the cementitious matrix is based on Portland cement and includes pozzolanic material such as flyash, silica fume, slag and combinations thereof.

18. The pipe of any one of claims 1 to 16, wherein the cementitious matrix comprises an alkali-active cement based on a pozzolanic material such as flyash, silica fume and combinations thereof.

19. The pipe of claim 17 or claim 18, wherein the cementitious matrix has discontinuous fibers dispersed therethrough, such as metallic, polymeric, ceramic fibers, and combinations thereof, in relatively short fiber length of from 3mm to 24mm in length.

20. The pipe of any one of claims 1 to 19, wherein the cementitious material is an engineered cementitious composite.

21. The pipe of any one of claims 1 to 20, wherein the pipe is produced by dewatering extrusion of a suitable cementitious material having a water content providing a ratio of water to binder (cement plus pozzolanic) of about 0.3 to 0.5, and wherein the ratio is reducing during extrusion to about 0.24 to 0.26.

22. The pipe of any one of claims 1 to 21, wherein the pipe has a value for Young's modulus of from 20 GPa to 40 GPa, such as from 30 GPa to 35 GPa.

23. The pipe of any one of claims 1 to 22, wherein the pipe has a compressive strength of from 40 to 100 MPa, such as from 45 to 75 MPa, for example 50 to 70 MPa.

24. The pipe of any one of claims 1 to 23, wherein the matrix crack strength is from 4 to 12 MPa, such as from 5 to 10 MPa, for example 5 to 7 MPa.

25. The pipe of any one of claims 1 to 24, wherein the pipe has a composite failure stress of from 5 to 14 MPa, such as from 6 to 12 MPa, for example 6 to 9 MPa.

26. The pipe of any one of claims 7 to 25, wherein the pipe has a composite failure strain of from 2 to 8%, such as from 3 to 6%, for example 3 to 5%.

27. A method of producing cementitious pipe suitable for below ground use, wherein said method includes forming a pipe having a tubular wall of fiber-reinforced cementitious matrix or material capable of exhibiting pseudo strain hardening (PSH) behavior, said wall having a wall thickness to diameter ratio within a range, and wherein said forming and the cementitious material are controlled whereby the range for said wall thickness to diameter ratio is such that the pipe exhibits characteristic behavior in diametral quasi-static bending (flexure) when subjected to the 3-edge bearing method, and such said behavior is such that a resultant stress versus relative displacement curve for the pipe when subjected to that method exhibits a substantially linear elastic region having a first slope within first limits and, from the limit of proportionality (LOP) for the elastic region to the modulus of rupture (MOR) for the pipe, a PSH region which, beyond a possible transition region, has a slope which is less than that of the elastic region and is within second limits.

28. The method of claim 27, wherein the forming is controlled such that the wall has a relatively low wall thickness to diameter ratio.

29. The method of claim 27 or claim 28, wherein forming is controlled such that the for a given wall diameter, the wall thickness is within a relatively narrow range, with the wall thickness range for a pipe having a wall of a given larger diameter being greater than the wall thickness range for a pipe having a wall of a given smaller diameter.

30. The method of claim 29, wherein forming is controlled such that the wall thickness range for a given wall internal diameter is as follows for the indicated pipe wall internal diameters:

| Wall Diameter | Wall Thickness Range |
|---|---|
| 225mm | 5 to 9mm |
| 375mm | 8 to 15mm |
| 750mm | 16 to 30mm |

| | |
|---|---|
| 2100mm | 45 to 85mm |

31. The method of claim 29, wherein forming is controlled such that the wall thickness range for a given wall internal diameter is as follows for the indicated pipe wall internal diameters:

| Wall Diameter | Wall Thickness Range |
|---|---|
| 225mm | 6 to 8mm |
| 375mm | 9 to 13mm |
| 750mm | 20 to 26mm |
| 2100mm | 55 to 75mm |

32. The method of any one of claims 27 to 31, wherein said forming is controlled such that the tubular wall is of substantially circular cross-section and of substantially constant cross-sectional form substantially throughout its length.

33. The method of any one of claims 27 to 32, wherein the cementitious matrix is selected from a matrix based on:

(a) Portland cement and includes pozzolanic material such as flyash, silica fume, slag and combinations thereof; or

(b) an alkali-active cement based on a pozzolanic material such as flyash, silica fume and combinations thereof.

34. The method of claim 33, wherein the cementitious matrix has discontinuous fibers dispersed therethrough, such as metallic, polymeric, ceramic fibers, and combinations thereof, in relatively short fiber length of from 3mm to 24mm in length.

35. The method of any one of claims 27 to 34, wherein the cementitious material is an engineered cementitious composite.

36. The method of any one of claims 27 to 39, wherein the pipe is produced by dewatering extrusion of a suitable cementitious material having a water content providing a ratio of water to binder (cement plus pozzolanic) of about 0.3 to 0.5, and wherein the ratio is reduced during extrusion to about 0.24 to 0.26.